01P04078 58

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 126 174 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 83105037.2

(22) Date of filing: 20.05.83

(51) Int. Cl.³: B 22 D 17/32, B 29 F 1/06

(43) Date of publication of application: 28.11.84
Bulletin 84/48

(84) Designated Contracting States: AT BE CH DE GB LI LU NL SE

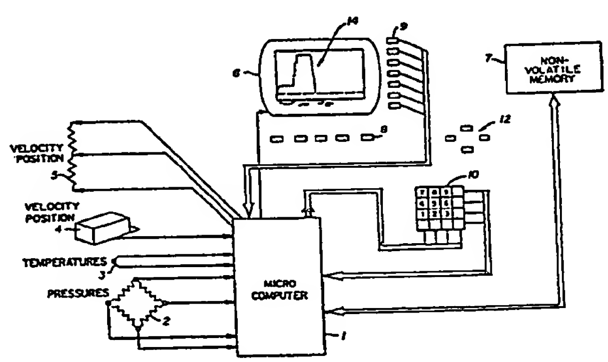
(71) Applicant: Mickowski, John, 127 Main Street, Franklin New Jersey 07416 (US)

(72) Inventor: Mickowski, John, 127 Main Street, Franklin New Jersey 07416 (US)

(74) Representative: Kinzebach, Werner, Dr., Patentanwälte Reitstötter, Kinzebach und Partner Postfach 780, D-8000 München 43 (DE)

(54) Process for monitoring and controlling intermittently working molding and casting devices and apparatus for performing said process.

(57) Process for monitoring and controlling intermittently working molding and casting devices having reciprocating means for intermittently transferring raw material at defined operation parameters, velocity, temperature, and pressure wherein the process comprises the steps of measuring one parameter of the reciprocating means during reciprocation movement; storing the value of said parameter as a function of position of the reciprocating means; displaying at least said value of said parameter as a funcation of position so as to obtain a profile of said parameter of the current molding or casting process; superimposing on said current parameter profile at least one master profile previously being obtained during a prior molding or casting process which resulted in a product of desired characteristics; controlling the working parameters of the reciprocating means so as to obtain a current parameter profile similar to the master profile.



EP 0 126 174 A1

M/24 099

Various industrial processes employ reciprocating machinery having a linear stroke to implement the process. In die casting and plastic molding, for example, the linear reciprocating device is an hydraulic cylinder used for loading raw material into the die or mold respectively. In die casting, molten metal is forced into the die from the hydraulic cylinder by a piston type plunger or ram displaced over a linear stroke under controlled operating conditions of pressure and velocity. Research in die casting has achieved a level of sophistication whereby the proper injection speeds, pressure and temperatures required for optimum operation for any given machine can be theoretically calculated. To satisfy the calculated conditions, the operation must be carried out within narrow ranges of settings for each of the critical process parameters. Variation in one or more of the process parameters will affect the performance of the other parameters on the process and will alter the production rate and affect the yield of the product produced. To optimize the production output the process parameter settings are adjusted over a series of production runs until a product with desired characteristics and production yield is obtained. Since the events which affect the production cycle occur much too quickly for human observation it was necessary, heretofore, for operating personnel t make subj ctive judgements in adjusting proc ss paramet rs in a production run frequently resulting in high scrap rates. Th trial and error

technique commonly used her tofore also required more raw material than necessary in getting a given required production output. Moreover, because of the inability to control and adjust the process parameters accurately, the design of the article produced typically had to be made with more material than necessary for functional or strength considerations simply to permit an acceptable yield.

Accordingly, a need exists for a diagnostic instrumentation system which can readily be applied to the process machinery to monitor and record objective measurements of machine performance during an actual production cycle. The objective measurements should represent machine operational data which will provide technical personnel with the means to make appropriate adjustments to maintain optimum process integrity. Prior art instrumentation claiming to satisfy this need are based upon the use of high speed analog graphic plotters which typically use expensive ultraviolet sensitive photographic paper in combination with transducers and signal conditions designed to collect machine data and display it. One of the major disadvantages to the use of a graphic plotter is that its output is a graphical display of the given parameter under observation versus time. A time display is difficult to interpret and requires sophisticated expertise to derive and calculate quantitative values f r the critical parameters aff cting the process.

Not only is the interpretation subject to error but it does not provide readily apparent information from which machine adjustments may be made in the next production cycle. Another significant disadvantage is that the oscillographs must be adjusted to accommodate the transducers used on a specific machine and must be calibrated for each different type of transducer. Also, because of the high speed of the paper travel of the recorder it is necessary for a technical person to be constantly attentive of the oscillograph so as to minimize the waste of the expensive paper.

Starting from the above state of the art it is the task of the present invention to provide a process and an apparatus for performing said process by which the time and costs for setting up a molding or casting system to produce a new product is minimized.

This task is solved by a process for monitoring and controlling intermittently working molding and casting devices having reciprocating means for intermittently transferring raw material at defined operation parameters, velocity, temperature, and pressure, wherein the process is characterized in that the process comprises the steps of

a) measuring at least one parameter of the reciprocating means during reciprocation movement;
b) storing the value of said parameter as a function of position of the reciprocating means;
c) displaying at least said value of said parameter as a function of position so as to obtain a profile of said parameter of the current molding or casting process;
d) superimposing on said current parameter profile at least one master profile previously being obtained during a prior molding or casting process which resulted in a product of desired characteristics;
e) controlling the working parameters of the reciprocating means so as to obtain a current parameter profile similar to the master profile.

Further, different improvements of the present invention can be derived from the subclaims and the following description.

The data analysis and display system of the present invention provides a graphic display of one or more process parameters for controlling the operation of a reciprocating device having a linear stroke as a function of stroke position. In a die casting operation the reciprocating device would be representative of the hydraulic cylinder and piston ram for injecting raw material into the die. The data analysis and display system of the present invention would automatically generate a profile f the critical perational para-

meters, viz., velocity and pressure as a function of ram position along its linear stroke. This permits dramatically reduced set up time and readily provides information for adjustment of the variable parameters within precise limits to assure maximum production quality and performance.

It is the principal object of the present invention to provide a data analysis and display system for generating a profile of at least one process parameter in the control of a reciprocating device having a linear stroke as a function of stroke position.

It is a further object of the present invention to provide a data analysis and display system for monitoring a reciprocating device in an industrial process through transducers adapted to provide automatic zero offset calibration adjustment.

It is an even further object of the present invention to provide a data analysis and display system adapted to store in a non-volatile memory of a microcomputer a profile recording of a master trace for a given control parameter so as to provide for the superposition of a current profile of such control parameter upon the master trace.

It is yet a further object of the present invention to provide a data analysis and display system for generating on a cathode ray tube the profile of at least one process parameter affecting the operation of a reciprocating device having a linear stroke as a function of stroke position and for generating a cursor for providing quantitative information of such process parameter at any cursor position along said profile.

Other objects and advantages of the present invention will become apparent from the following detailed description of the apparatus according to the invention when read in conjunction with the accompanying drawings of which:

Figure 1 is a block diagram of the data analysis and display system of the present invention;

Figure 1A is a pictorial representation of a typical profile display of velocity versus position generated in accordance with the present invention for a die casting operation;

Figure 2 shows the pressure interface circuit between the microcomputer of Figure 1 and the pressure transducer;

Figure 3 shows the temperature interface circuit between the microcomputer of Figure 1 and the temperature transducer;

Figure 4 shows the position transducer interface circuit between the microcomputer of Figure 1 and the position transducer;

Figure 5 is a flow diagram for the microprocessor of Figure 1 corresponding to the start function;

Figure 5A is a flow diagram identifying the software functions for the program selection "Collect Data" in the flow diagram of Figure 5;

Figure 6 is another flow diagram identifying the software functions for the "Graphics" program selection in the flow diagram of Figure 5;

Figure 6A is a flow diagram subroutine for performing the "Plot" function in the flow diagram of Figure 6;

Figure 6B is a flow diagram subroutine for performing the "Current", "Master" and "Plot Variable" subroutines of the Plot function of Figure 6A;

Figure 6C is a flow diagram subroutine for performing the "Cursor" subroutine for the Cursor function of Figure 6;

Figure 6D is a flow diagram subroutine for performing the "Files" function in the flow diagram of Figure 6;

Figure 6E is a flow diagram subroutine for performing the "Get Old" and "Make New" subroutines of the Files function of Figure 6C; and

Figure 7 is a flow diagram for carrying out the ENTER/EDIT PARAMETER SHEETS function in the flow diagram of Figure 6.

Referring now in particular to Figure 1 and Figure 1A inclusive which diagrammatically illustrate the data anlysis and display system of the present invention and a typical CRT (cathode ray tube) velocity profile generated by the system of the present invention for a die casting machine.

The basic building blocks of the data analysis and display system of the present invention comprise a microcomputer 1 of any conventional design, including a conventional non-volatile memory 7, groups of program selection and function keys 8, 9 and 12 and a numeric keyboard 10; a plurality of transducers 2, 3, 4 and 5 respectively and a conventional cathode ray tube 6 hereinafter referred to as a CRT.

The transducers 2, 3, 4 and 5 represent pressure, temperature and velocity position transducers respectively. Transducers 4 and 5 represent alternative transducers for providing velocity position data to the microprocessor. Transducer 4 is a conventional digital type transducer connected to the die casting machine to sense the pulses generated during machine production in response to each incremental movement of the reciprocating device (not shown) over its linear stroke. The output is in a binary coded decimal format for direct reading by the microcomputer 1. The transducer 5 is a linear potentiometer having an interface circuit as will be discussed in more detail with reference to Figure 4. The microcomputer 1 may interface to either the digital velocity position transducer 4 or the linear potentiometer velocity position transducer 5. The temperature transducer 3 is a temperature thermocouple having an interface circuit as will be discussed in more detail with reference to Figure 3 whereas the pressure transducer 2 is a conventional strain gage type pressure transducer in a bridge configuration with an interface circuit as will be discussed in more detail with reference to Figure 2.

Each of the transducers 2, 3, 4 and 5 collect data consisting of velocity, temperature and pressure

as a function of strok positi n during a production cycle. The production cycle for a die casting or plastic molding operation is defined for purposes of the present invention as the stroke and corresponds to the motion of the injection ram (not shown) which injects either metal into the die or plastic into a mold respectively. The stroke length represents the total displaced distance of the injection ram in the hydraulic cylinder for a single production cycle.

The conventional microcomputer 1 is connected to a conventional CRT 6 for displaying a profile representative of the data collected by the transducers 2, 3, 4 or 5 in accordance with programmed instructions corresponding to the flow diagrams 5, 6, 6A-6F and 7 respectively as will be discussed in more detail hereafter. Any conventional software program format suitable for use with the microcomputer 1 may be used in the preparation of a program to fulfill the flow diagram requirements. The program itself does not form a part of the present invention and may readily be prepared by any skilled programmer from the flow diagrams.

An illustrated display of a typical profile 14 representative of the velocity of the injection ram for a production cycle as a function of stroke position, i.e., the position of the reciprocating injection ram along the stroke length, is shown on

the CRT 6. A further illustrative display shown two velocity traces superimposed for comparison is shown in Figure 1A. The microcomputer 1 is of any commercially available type which can generate a cursor. The position of the cursor 16 in Figure 1A is controlled by software following the flow diagram subroutine for the cursor to be discussed hereafter in connection with Figure 6C and Figure 7. The cursor 16 is adjustable over the stroke length and provides specific parameter information corresponding to its location on the display thereby permitting the observer to readily compare parameter values between the superimposed traces at any stroke position. One of the superimposed traces may represent a "master" profile defined as an idealized or acceptable profile and may simply represent a previously recorded profile. A master profile is used for comparison purposes with a "current" profile. A current profile is defined as a profile trace formed on the CRT from data received by the microprocessor from one of the transducers in response to a current production cycle. The master profile is stored in the non-volatile memory 7. Any number of master profiles may be recorded and stored in the non-volatile memory 7 so as to constitute a library of master profiles. A master profile is stored at any address in memory 7 identified by the operator through the use of the numeric keyboard 10. By providing this ability to superimpos master profiles over a current

profiles, a non-technically trained person can readily distinguish between a master trace identifying a production run classified as acceptable or good and the current production run representing the current profile. It also becomes readily apparent to the operator where and to what extent adjustment may be necessary to conform subsequent production runs to the master trace. This is primarily attributable to the fact that the trace is a function of position and not time. Individual program selection and function control is provided by groups of push buttons 8, 9 and 12. Each individual button in group 9 is assigned a program selection whereas the group of push buttons 8 and 12 are assigned individual function selections corresponding to the function selections in the flow diagrams. The numeric keyboard 10 additionally provides for the numeric entry of upper and lower limits for each important parameter so as to define the acceptable range of such parameter for proper operation of the machine. In addition, the numeric keyboard 10 may be used to enter data corresponding to a machine number, ram plunger diameter and production cycle job number which collectively are used for the file identification for each master trace stored in the non-volatile memory 7.

Figure 2 shows the pressure interface circuit between the microcomputer 1 and the pressure transducer 2. The pressur transduc r 2 is f a conventional bridge type with one leg of the bridg being adjustable and varying in a conventional fashion in response to the

amount of resistance to movement of the reciprocating device (not shown). Resistors R1, R2 and R3 form a zero offset adjustment network to cancel out the zero offset of the pressure transducer 2 so as to provide a zero differential input to the operational amplifier U1. Resistors R4, R5, R6, R7 R8 and R9 form an appropriate feedback network to provide an output 18 of predetermined gain relative to the signal 19. RC network combination R7 and C1 reduce the noise content from the pressure transducer 2. Integrated circuit 20 is a commercially available analog to digital converter for converting the analog signal to a digital format preferably in BCD form. The resistors R11, R12, R13, R14, R25, R26 and R27 are pull up resistors for providing signals on lines AD, BD and MNL which are connected to provide the microcomputer 1 with continuous data corresponding to the pressure at the instant of time selected to be read by the microcomputer. The microcomputer 1 reads the pressure data in increments of time corresponding to the incremental displacement of the reciprocating device (not shown) over the stroke length to provide a profile of pressure versus stroke position. Resistors R16 and R23 are selected to cancel

the zero offset of the analog to digital converter 20. Capacitor C2 is an integrating capacitor used by converter 20 during data conversion. Register R22 is used to adjust the gain of the converter 20 to result in a calibrated output.

Figure 3 shows the temperature interface circuit between the temperature transducer 3 and the microcomputer 1. Thermocouple 41 is adapted to be coupled to the reciprocating device to provide a temperature signal corresponding to the temperature in the reciprocating device as a function of stroke position. The thermocouple 41 is connected through lead lines 25 and 26 to a conventional operational amplifier U2. Resistors R28 and R29 provide the feedback resistors for setting the gain of the first stage of amplification. A second stage of amplification is provided by a convention operational amplifier U3 in conjunction with its feedback resistor network R30, R31, R32, R35 and R34. The output 30 from the second stage of amplification is fed relative to the potential on line 33 to a conventional analog to digital converter 32 in a manner similar to that in the interface circuit for the pressure transducer 2. The output from the analog to digital converter 32 is provided on the same lines LM N, AB, CD as for the pressure transducer circuit in Figure 2.

Figure 4 shows the linear potentiometer interface circuit between the linear potentiometer 5 and the microcomput r 1. The linear potentiometer 5 may be readily mounted to the die casting machine with its variable wiper

arm 35 connected to move with the reciprocating device. Accordingly, the position of the wiper arm 35 is directly proportional to the position of the reciprocating device along the stroke length. Since the velocity of the reciprocating device is equal to distance divided by time; the velocity is readily determined relative to each incremental stroke position. The stroke length may be divided into any number of increments with the velocity representing the differential of each reading with respect to time.

Linear potentiometer 5 is connected to the interface circuit operational amplifier U4, U5 and U6 respectively. Operational amplifiers U4 and U5 serve to apply positive and negative reference voltage levels across the opposite ends 36, 37 of the potentiometer 5. The operational amplifier U6 amplifies the signal output 38 from the wiper arm 35. Operational amplifier U4 and U6 are connected in a conventional unity gain configuration. Resistors R54 and R55 form a unity gain feedback circuit which generates a positive reference voltage on end 36 of potentiometer 5 equal in magnitude to the negative reference voltage developed by zenor diode 60 from a negative power supply voltage -V through resistor R56. Accordingly, the output 40 of the operational amplifier U6 is automatically adjusted against drift in power supply voltage. The output 40 is connected to a conventional analog to digital converter 42 such as Beckman AD7556. The data present d n the data bus lines Bo through B7 are c nn cted

to the microcomputer 1. The A to D converter 42 generates a twleve bit digital signal corresponding to the analog signal 40. Or gates 71, 72 and 73 control the conversion of data and the interrogation of the twelve bit output DO through D11 of the A to D convertor 42. Each time the microcomputer takes a reading the enable conversion line 74 goes to the zero logic state. At the same time, address lines 75 and 76 are set to a logical zero. When all three of the signals are logical zero's the output of Or gate 72 is a logical one thereby enabling the low byte labeled LBI in the A to D converter 42. This causes the lower significant bits DO through D7 to be impressed upon the data bus lines BO to B7. After reading the lower eight bits, the microcomputer 1 then interrogates the upper four bits D8 to D11 by setting the enable conversion line to a zero logic state while setting address lines 77 and 76 to logical zero. This combination causes the output of Or gate 73 to go to a logical one which, in turn, enables the end of Conversion Signal EocI and the high byte HBI causing the upper significant bits D8 to D11 to be impressed upon the data bus lines BO to B3. The conversion of data is initiated when the microcomputer sets the enable conversion line 74 to a zero logic state and sets the address lines 78 and 76 to logical zero. This causes the output of Or gate 71 to go to a high state thereby impressing a start signal to the start input of th A to D converter 42 for starting another conversion cycle. By continuously repeating the

start conversion and reading sequence in predetermined intervals corresponding to incremental distances the microcomputer 1 knows at all times what the position of the ram is along the machine stroke. Upon collecting the position data as a function of time it need only perform an algorithm representing a simple mathematical quotient of distance and time to convert the position data to velocity data. Accordingly, a profile can be generated corresponding to velocity versus position as well as velocity versus time or a combination of both. The latter is significant in that certain periods may exist when a momentary time display would be beneficial. In die casting this is true at approximately the end of the stroke where the velocity of the ram approaches zero. Accordingly, a combination display is particularly useful for the pressure profile in a die casting operation over the final stroke length known to those skilled in the art as the "biscuit" length.

Figure 5 illustrated the flow diagram for start up of the microcomputer 1. Upon depressing the start function key three program selections identified as Collect Data, Graphics and Entry/Edit Parameter sheets become selectable. A program is selected by depressing one of the dedicated function keys corresponding to the program selection. Any one of the keys in the function key groups 8, 9 and 12 may be assigned the appropriate functions.

Figure 5A shows the flow diagram for the program selection "Collect Data". The letter (N) designates each incremental position at which data is to be collected over the stroke length. The stroke length may be divided into any fixed number of incremental data collection points preferably corresponding to the screen increments for the particular microcomputer being used. At each data collection point a time reading is taken with the number of the data points designated IT. The start position is labeled SØ at time IT Ø whereas the current position of the injection ram along the stroke length is designated SI. The algorithmic statement SI $\geq$ SØ + E is met only when the ram has advanced from the start position a fixed distance E representing the desired incremental spacing between the incremental positions. Once this is met the incremental position N is advanced by one and a reading is taken from the transducers 2, 3, 4 or 5 of current velocity, current temperature, and current pressure-The microcomputer clock is used for generating a time frame.

The program of Figure 5A provides for consecutive readings at each incremental position until the assigned number of incremental positions reaches maximum. In die casting near the end of the operation when the ram approaches the end of the stroke the velocity will drop to a plateau level of slightly above zero at which time it is preferred t continue readings as a function of time. Accordingly, as shown in Figure 5A, a time frame is stablished for the remaining number of incremental positions with tØ representing the starting time for

further consecutive readings as a function of time. As soon as the current time t(N) plus a predetermined time increment "δ" is reached representing a time data increment IT within the established time frame, from tØ to IT maximum, the next reading is taken. At such instant the time data increment IT is advanced by one and further readings are taken until the increments of time IT equal the completion of the established time frame.

Figure 6 shows the flow diagram for the program Selection Graphics. With this program selection the operator is given a further choice of the subordinated functions Plot, Cursor, Frame, Files and Quit. Any one of these functions become available upon depression of one of the assigned function keys 8. The Erase function clears the screen and return the program selection. The program selection is also returned upon depressing the quit function key.

The Plot function is shown in Figure 6A providing further selection of the subroutines Master or Current. Figure 6B shows the flow diagram for both the master and current subroutine for the function selection Plot. The subroutine is the same whether current data or master data is plotted with the data of each of the variables loaded and plotted corresponding to each incremental position. The Cursor function flow diagram is shown in Figure 6C. A vertical line is plotted at the existing incremental position on the CRT screen upon

selection of the cursor with corresponding variables for the cursor position printed on the display for either a master or current profile. The cursor position is adjustable by the operator to either the left or right of the displayed cursor position by depression of the assigned dedicated function keys for cursor left or right control. The cursor will move in increments N preferably corresponding to the assigned incremental positions N for the stroke. Accordingly, the cursor position for one trace will automatically correspond to the same incremental position for a superimposed trace. As the flow diagram indicates the cursor may only be moved to the left or right to an incremental position which satisfies the statement defining the number of N positions.

In Figure 6D the flow diagram for the function selection "Files" is shown. The operator is provided with a further choice of subroutine selections "Get Old", "Make New", or "Quit". The subroutines "Get Old" and "Make New" is illustrated in Figure 6E. The files selection "Get Old" corresponds to the selection of a master trace whereas the files selection "Make New" corresponds to the storing of current data in forming a master trace in the non-volatile memory 7. The address number for the old or new master trace in the non-volatile memory is designated by use of the numeric keypad.

The Enter/Edit Parameter Sheet program selection identified in the flow diagram for start up of the microcomputer 1 is shown in Figure 7. The microcomputer 1 is instructed to go to the numeric keypad and wait for the operator to read in the numbers corresponding to the machine in use, the part in use and the machine type. The microcomputer assigns and constructs characters used for the file name. The parameters may then be printed out on the CRT screen. The screen prompt is adjustable to the left, right or up and down. The screen prompt refers to the flashing inverse video enhancement of the location on the CRT screen which the computer is currently monitoring. The user may at any time depress Fields complete to save the File name. The parameter sheet program may also be used to print out acceptable high and low limit settings.

In the above lines it was explained that the parameters of the piston plunger or ram is defined by manual settings corresponding to the resulting profiles. Obviously it is also possible to perform the settings by the microcomputer 1 itself by comparing the master- and the current profiles within the microcomputer. Especially in highspeed die casting production lines where the cycle is up to 600/h such an automatic optimizing process performed by the computer is advantageous, since the total production line works under normal conditions without interrupting.

Additionally, it is possible to perform an "ideal" trial and error optimization, i.e. a changing of a parameter resulting in a better fitting of the current profile to the master profile is prosecuted, the next trial starts from the changed parameters, a changing of parameters which results in a worse fitting of the curves is reset, the next trial starts from the previous parameter settings.

CLAIMS

1. Process for monitoring and controlling intermittently working molding and casting devices, having reciprocating means for intermittently transferring raw material at defined operation parameters, velocity, temperature, and pressure characterized in that the process comprises the steps of
   a) measuring at least one parameter of the reciprocating means during reciprocation movement;
   b) storing the value of said parameter as a function of position of the reciprocating means;
   c) displaying at least said value of said parameter as a function of position so as to obtain a profile of said parameter of the current molding or casting process;
   d) superimposing on said current parameter profile at least one master profile previously being obtained during a prior molding or casting process which resulted in a product of desired characteristics;
   e) controlling the working parameters of the reciprocating means so as to obtain a current parameter profile similar to the master profile.

1

2. Process according to claim 1, characterized in that said parameter is at least one of the velocity of the reciprocating means and/or the temperature and/or the pressure of the reciprocating device.

3. Process according to one of the previous claims, characterized in that profiles of different parameters are superimposed.

4. Process according to one of the previous claims, characterized in that the parameters are measured in intervals corresponding to incremental distances of reciprocating length.

5. Process according to one of the previous claims, characterized in that said parameters are measured, stored, and/or displayed as a function of time when the velocity drops below a predetermined level such that said parameter profile is automatically converted from a profile as a function of position to a profile as a function of time.

6. An apparatus for performing a process according to one of the previous claims, comprising a data analysis and display system for monitoring process parameters in the operation of a reciprocating device for graphically generating a profile (14) of such process parameters characterized by

a velocity position transducer (4,5) adapted to be connected to said reciprocating device for providing an output signal responsive to stroke position;

a microcomputer (1) programmed to read each output signal in intervals corresponding to incremental distances of stroke length and for converting each output signal to a velocity signal, means for causing each velocity signal to be controlled to form a velocity profile for said reciprocating device as a function of stroke length;

non-volatile memory means (7) for storing said velocity profile as a master trace;

means (10) for assigning an address location in said memory for said master trace; and

CRT means (6) for graphically displaying a first velocity profile (14) and for superimposing thereon another velocity profile (14a) from any master trace stored in the non-volatile memory (7).

7. An apparatus according to claim 6, wherein said velocity position transducer is a digital transducer (4) for automatically converting stroke position data into a digital format.

8. An apparatus according to claim 6, wherein said velocity position transducer is a linear potentiometer (54) having a variable wiper arm adapted to be connected to the monitored reciprocating device.

9. An apparatus according to claim 8 further comprising an interface circuit for converting the analog position represented by said variable wiper arm into digital information with said interface circuit comprising an operational amplifier (U 6), an analog to digital converter (65) and a logic gating circuit (71,72,73) for controlling the conversion of analog to digital data.

10. An apparatus according to claim 6, wherein said microcomputer (1) is further programmed to read each output signal as a function of time when said velocity drops below a predetermined level such that said velocity profile is automatically converted from a profile as a function of stroke position to a profile as a function of time.

11. An apparatus according to claim 10, further comprising a pressure transducer (2) for providing an output pressure signal corresponding to the pressure of said reciprocating device in response to stroke position and wherein said microcomputer (1) is programmed to read each output pressure signal in intervals corresponding to incremental distances of stroke length and for collecting each output pressure signal to form a profile of pressure as a function of stroke length until said velocity drops to below a predetermined level for continuing said profile as a function of time.

12. An apparatus according to claim 11 further comprising a pressure transducer circuit for converting said output pressure signal to a digital signal compatible for reading by said microcomputer.

13. An apparatus according to claim 12 further comprising means (10) for causing said pressure profile to be stored in said non-volatile memory (7) means as a master tracer thereof with said assignment means (10) providing an address location in said memory (7) for said pressure profile.

14. An apparatus according to claim 13 further comprising means for causing said pressure profile trace to be displayed upon said CRT (1) and for superimposing a master trace thereon of another pressure profile or other parameter profile.

15. An apparatus according to claim 10 further comprising a temperature transducer (3) for providing an output temperature reading of said reciprocating device in response to stroke position and wherein said microcomupter (1) is programmed to read each output temperature signal in intervals corresponding to incremental distances of stroke length and for collecting each output temperature signal to form a profile of temperature as a function of stroke length.

16. An apparatus according to claim 15 wherein said temperature transducer (3) is a temperature thermocouple and wherein said system further comprises an interface circuit for converting the analog output of said thermocouple (3) to a digital output.

17. An apparatus according to claim 16 further comprising dedicated function means for causing said temperature profile to be stored in said non-volatile memory means (7) as a master trace thereof with said assignment means (8,9,10,12) providing an address location in said memory for said temperature profile.

18. An apparatus according to claim 17 further comprising dedicated funcation means (8,9,10,12) for causing said temperature profile trace to be displayed upon said CRT (6) and for superimposing a master trace thereon of another temperature profile or other parameter profile.

19. An apparatus according to anyone of claims 6,11, and 15 further comprising cursor means (16) for causing the display of a cursor upon said CRT (6) corresponding to any incremental position along the stroke of said reciprocating device and means for horizontally adjusting the cursor display in incremental movements corresponding to said incremental distances between velocity position readings.

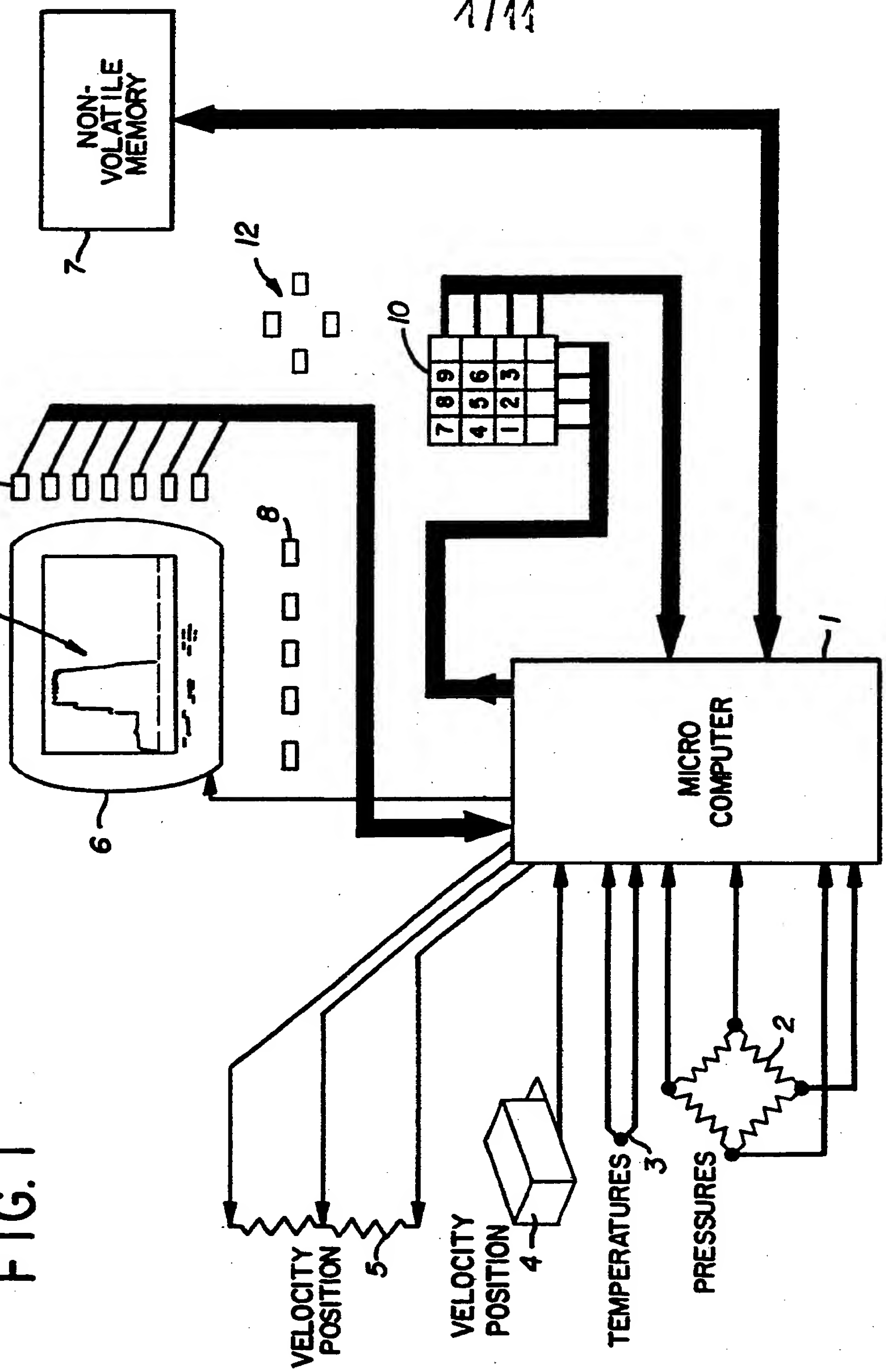

NON-VOLATILE MEMORY
7
12
10
9
14
8
6
MICRO COMPUTER
1
2
3
4
5
VELOCITY POSITION
VELOCITY POSITION
TEMPERATURES
PRESSURES

FIG. 1

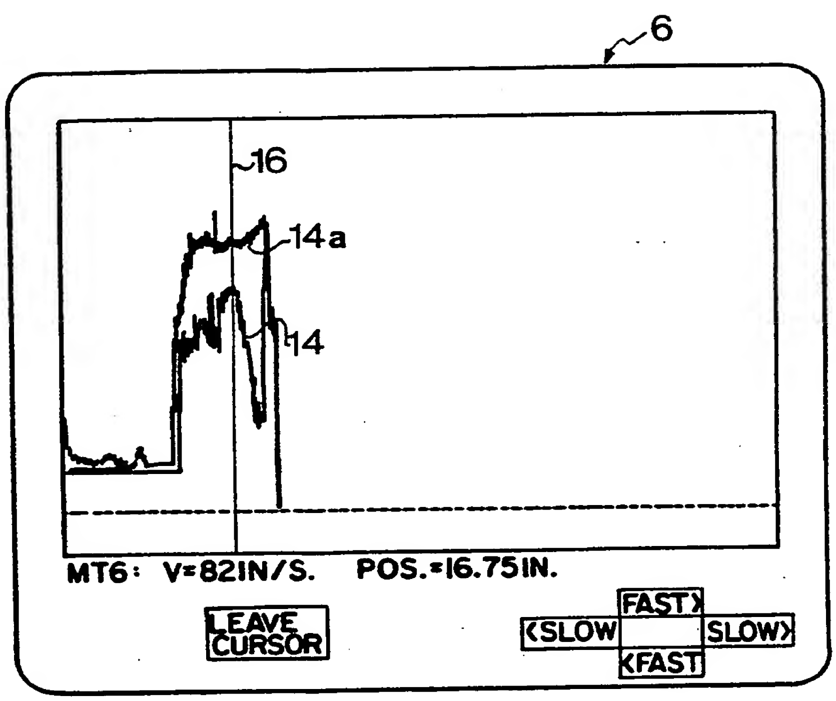

6
16
14a
14
MT6: V=82IN/S. POS.=16.75IN.
LEAVE CURSOR
FAST›
‹SLOW
SLOW›
‹FAST

FIG. 1A

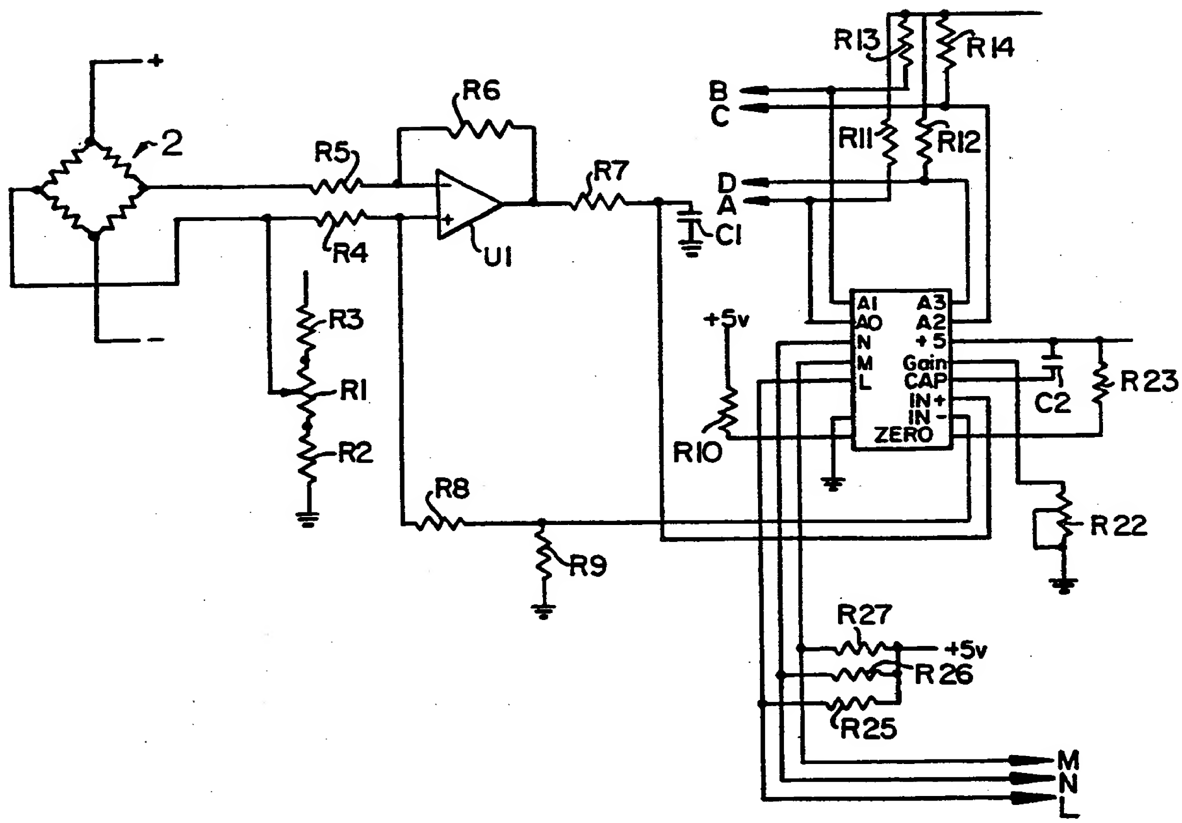

+
2
R6
R5
R4
U1
R7
C1
R3
R1
R2
R8
R9
−
R13
R14
B
C
R11
R12
D
A
A1
A0
N
M
L
A3
A2
+5
Gain
CAP
IN+
IN−
ZERO
+5v
R10
C2
R23
R22
R27
+5v
R26
R25
M
N
L

FIG. 2

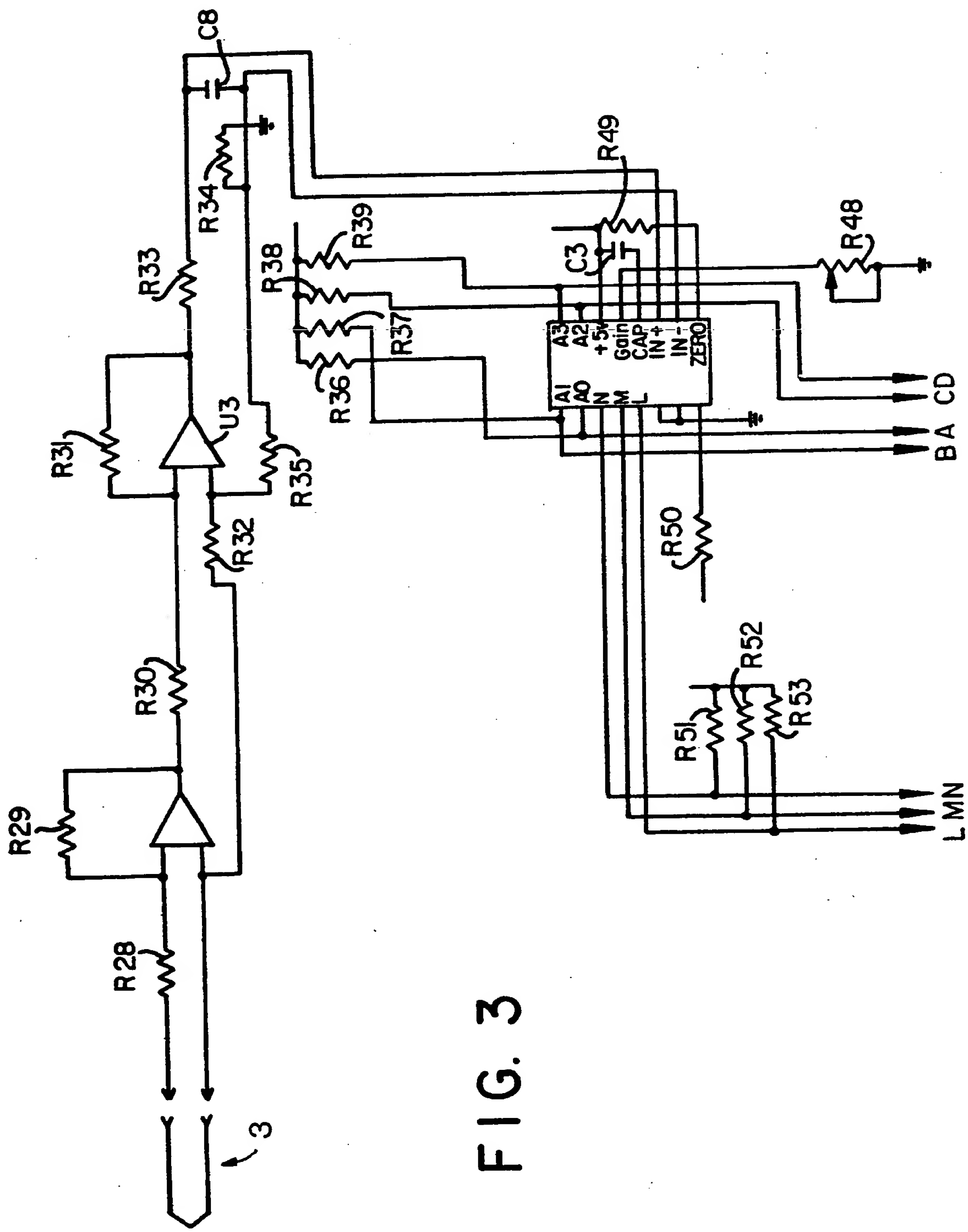

C8
R34
R33
R39
R38
R49
C3
R48
A3
A2
+5V
Gain
CAP
IN+
IN-
ZERO
A1
A0
N
M
L
R37
R36
U3
R31
R35
R32
R30
R29
R28
R50
R51
R52
R53
C D
B A
L M N
3

FIG. 3

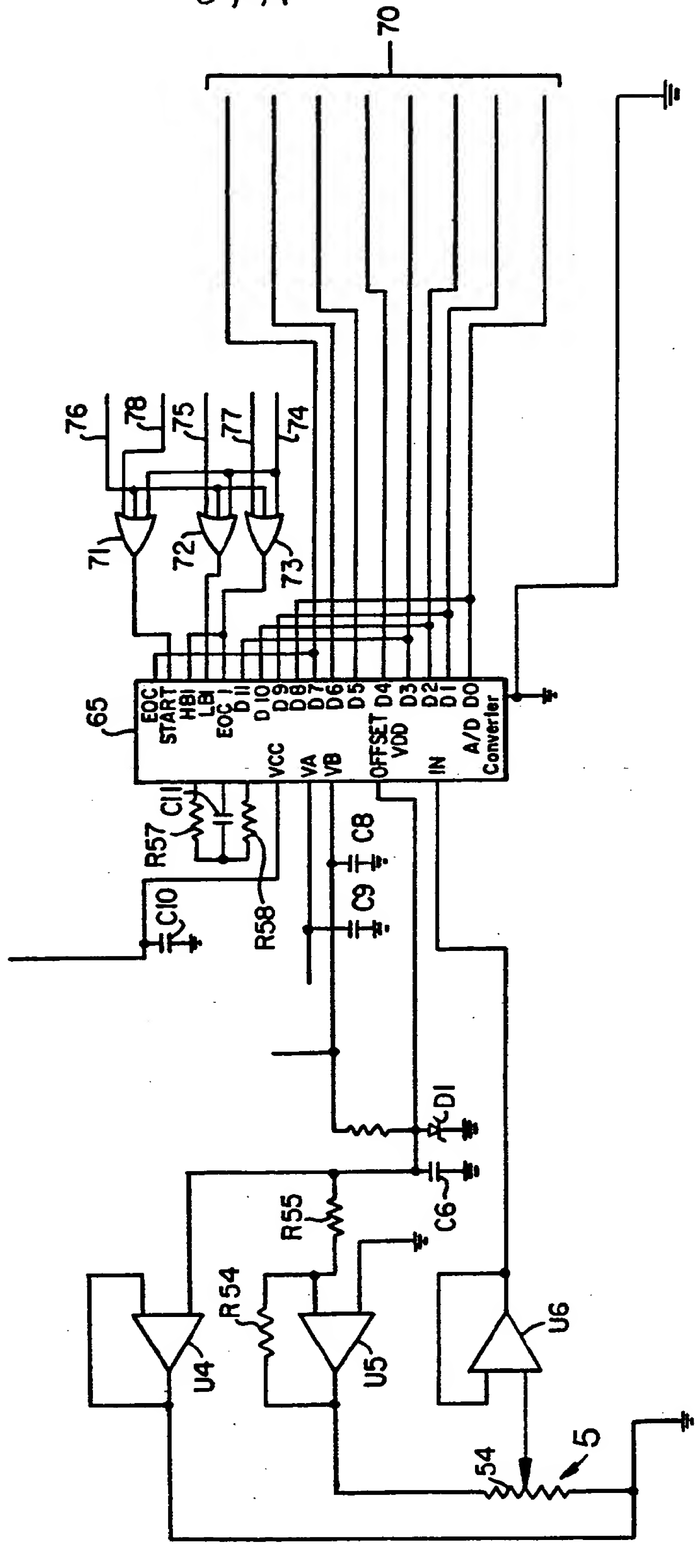

70
76
78
75
77
74
71
72
73
65
EOC
START
HBI
LBI
EOC I
D 11
D 10
D9
D8
D7
D6
D5
D4
D3
D2
D1
D0
VCC
VA
VB
OFFSET
VDD
IN
A/D
Converter
C11
R57
R58
C10
C8
C9
DI
C6
R55
R54
U4
U5
U6
54
5

FIG. 4

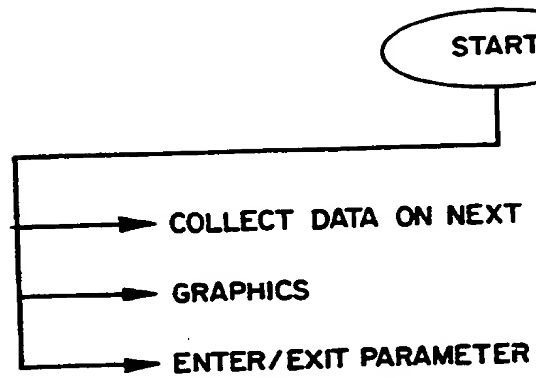


FIG. 5

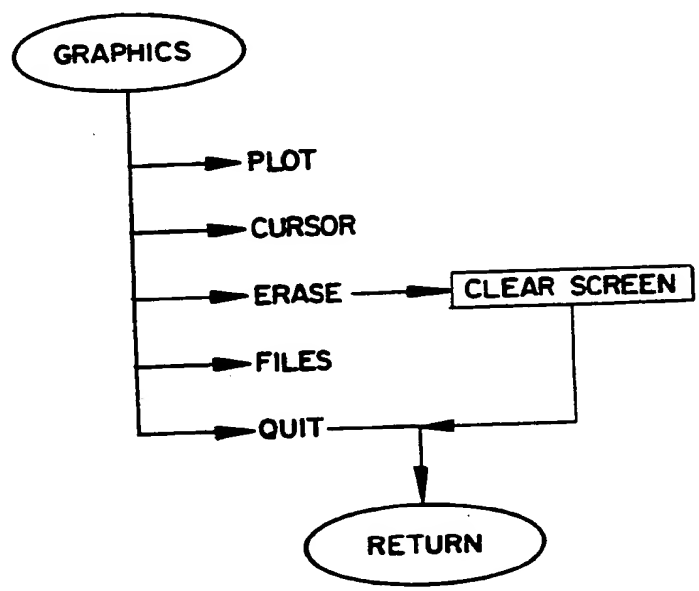


FIG. 6

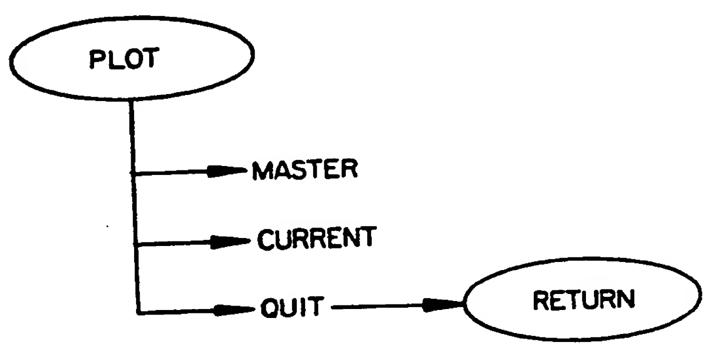
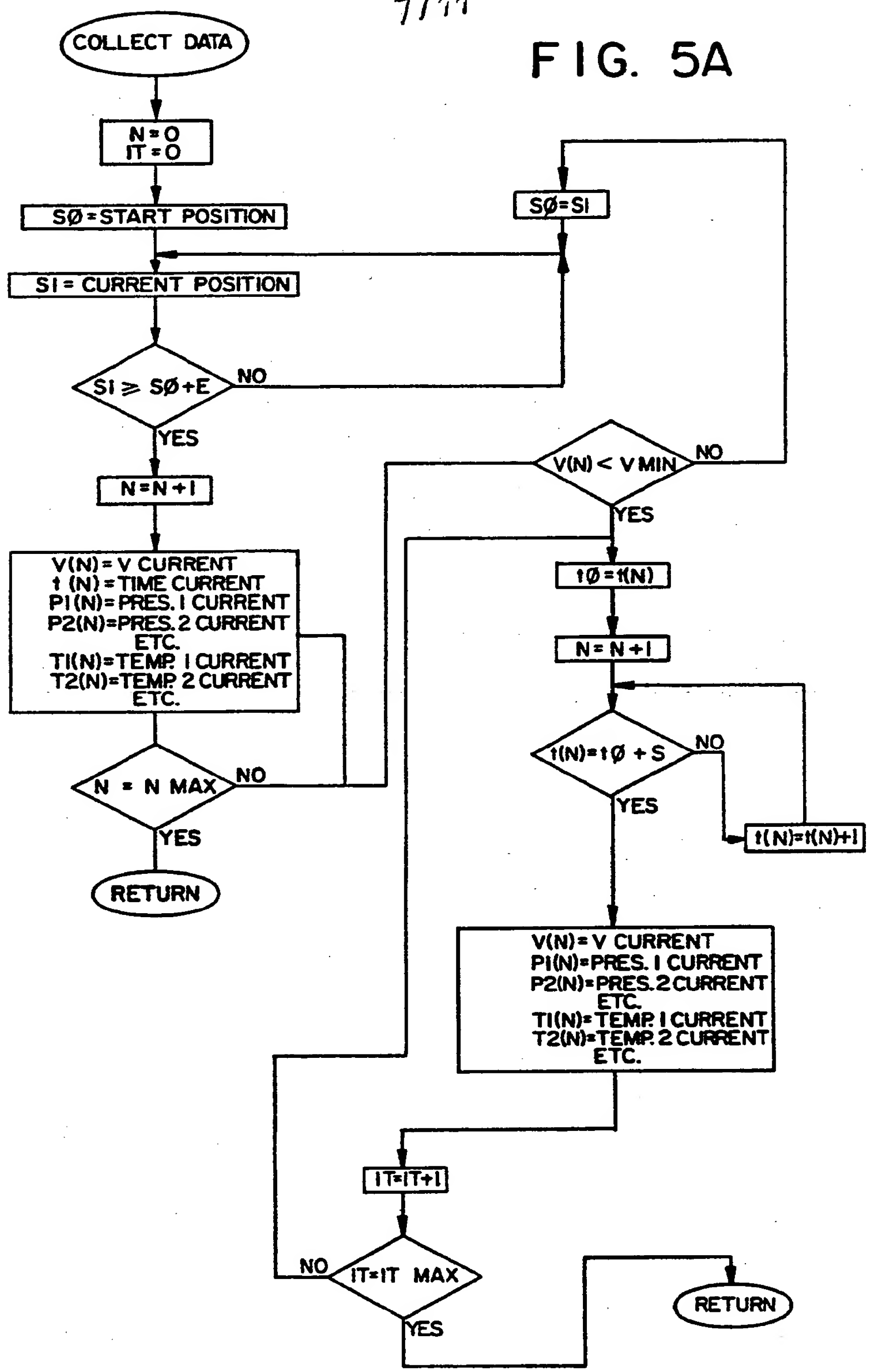


FIG. 6A

7/11

FIG. 5A


COLLECT DATA
N = O
IT = O
SØ = START POSITION
SØ = SI
SI = CURRENT POSITION
SI ≥ SØ + E
NO
YES
N = N + I
V(N) = V CURRENT
t (N) = TIME CURRENT
PI (N) = PRES. I CURRENT
P2(N) = PRES. 2 CURRENT
ETC.
TI(N) = TEMP. I CURRENT
T2(N) = TEMP. 2 CURRENT
ETC.
N = N MAX
NO
YES
RETURN
V(N) < V MIN
NO
YES
tØ = t(N)
N = N + I
t(N) = tØ + S
NO
YES
t(N) = t(N) + I
V(N) = V CURRENT
PI(N) = PRES. I CURRENT
P2(N) = PRES. 2 CURRENT
ETC.
TI(N) = TEMP. I CURRENT
T2(N) = TEMP. 2 CURRENT
ETC.
IT = IT + I
IT = IT MAX
NO
YES
RETURN

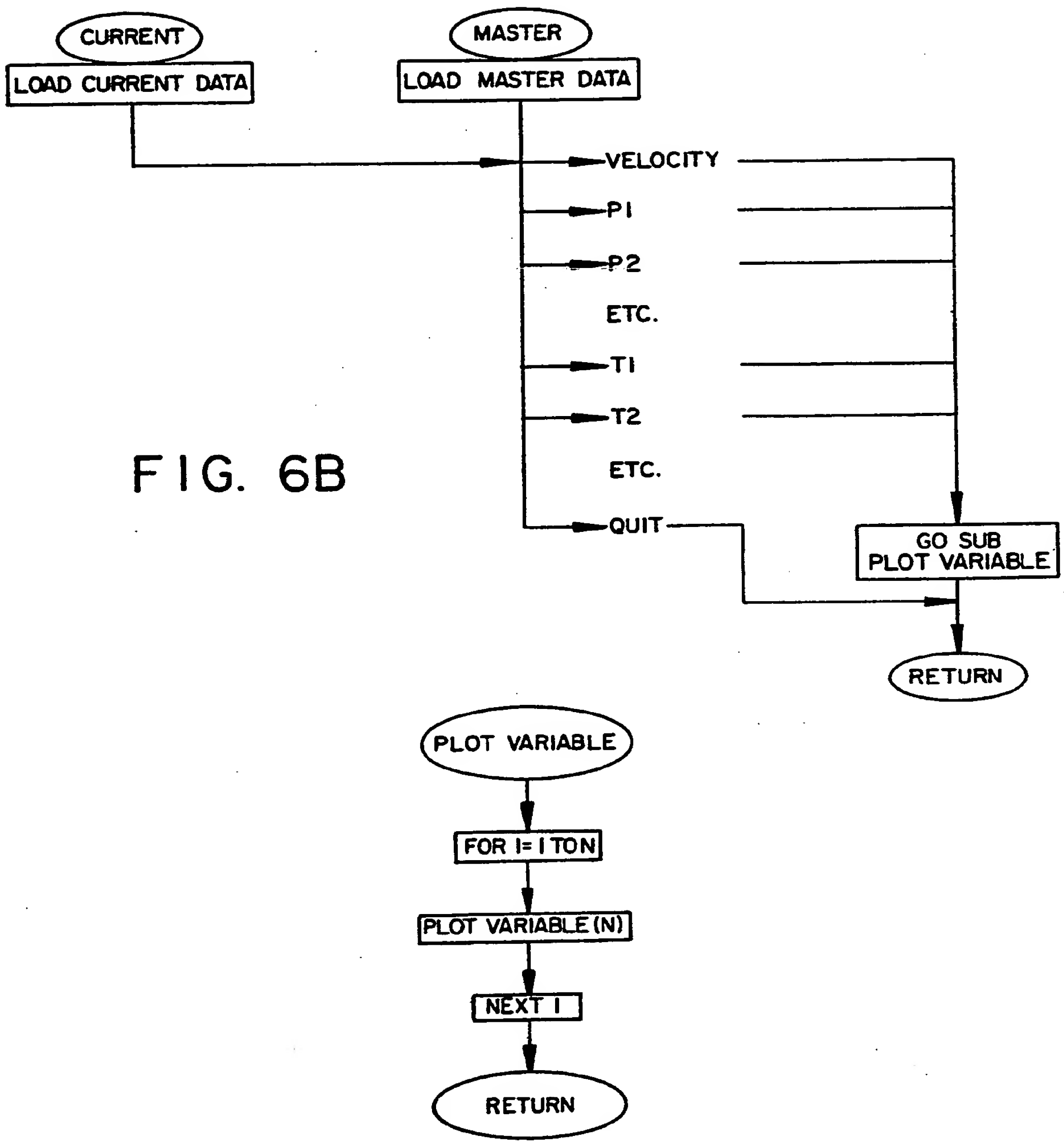

CURRENT
LOAD CURRENT DATA
MASTER
LOAD MASTER DATA
VELOCITY
P1
P2
ETC.
T1
T2
ETC.
QUIT
GO SUB
PLOT VARIABLE
RETURN
PLOT VARIABLE
FOR I=1 TO N
PLOT VARIABLE (N)
NEXT I
RETURN

FIG. 6B

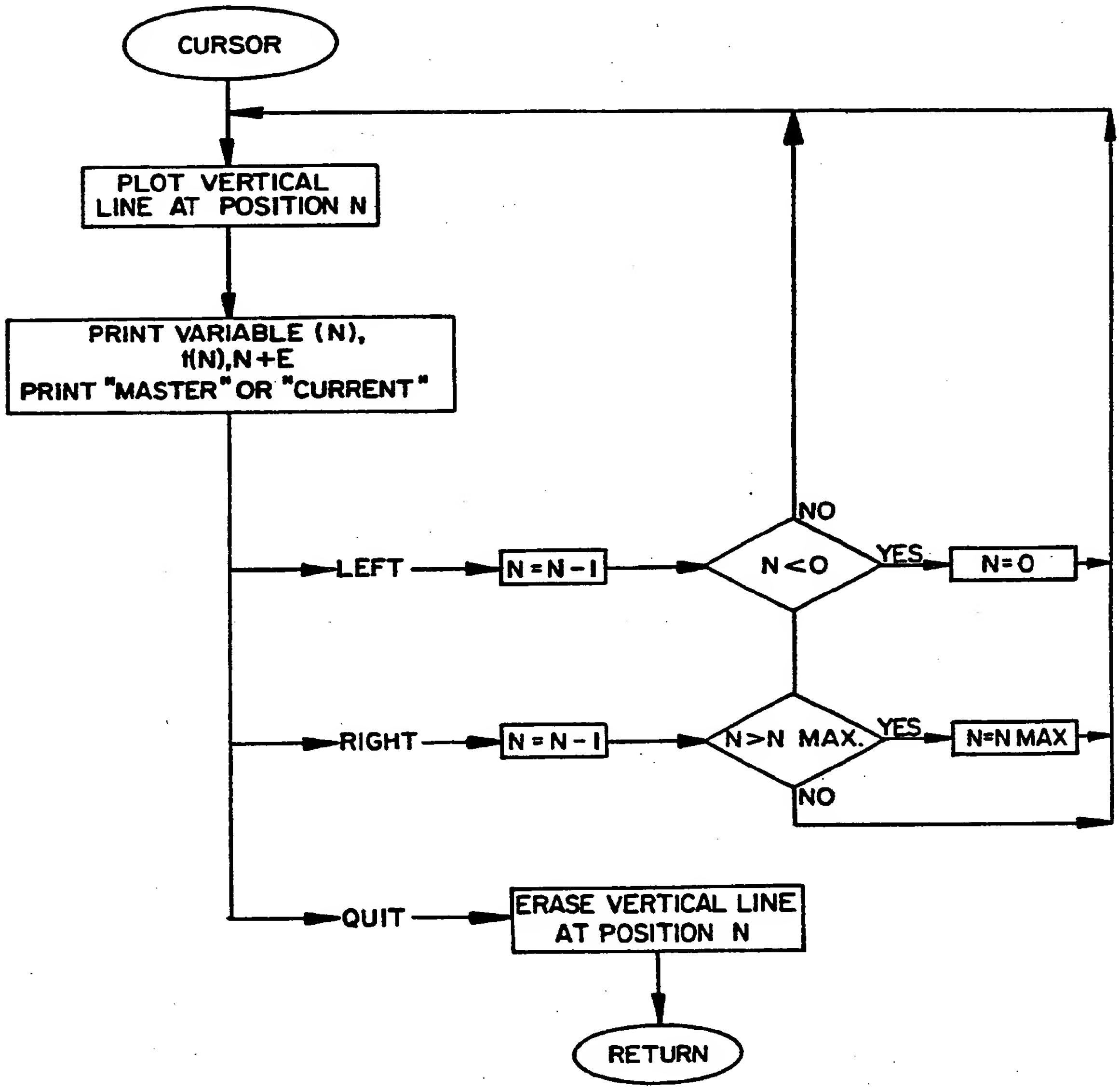
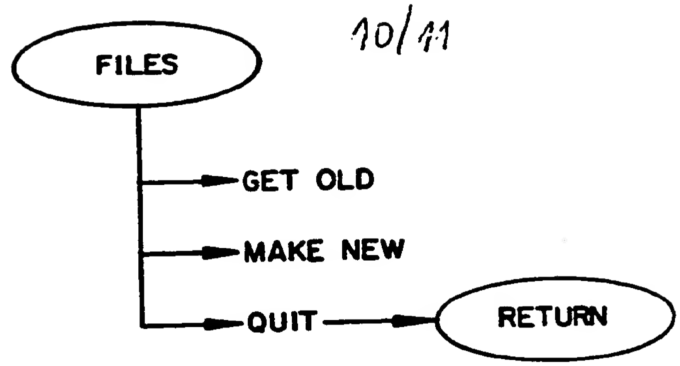

CURSOR
PLOT VERTICAL LINE AT POSITION N
PRINT VARIABLE (N), f(N),N+E PRINT "MASTER" OR "CURRENT"
LEFT
N=N-1
N<O
NO
YES
N=O
RIGHT
N=N-1
N>N MAX.
YES
N=N MAX
NO
QUIT
ERASE VERTICAL LINE AT POSITION N
RETURN

FIG. 6C

FIG. 6D


FILES
GET OLD
MAKE NEW
QUIT
RETURN

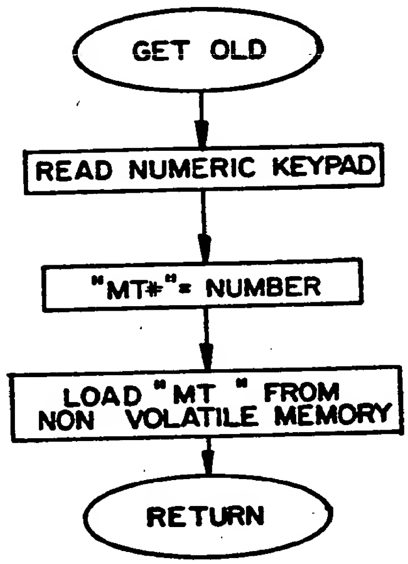

GET OLD
READ NUMERIC KEYPAD
"MT#"= NUMBER
LOAD "MT " FROM NON VOLATILE MEMORY
RETURN

FIG. 6E

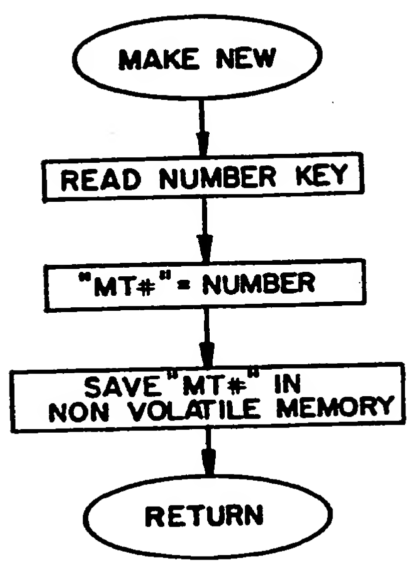
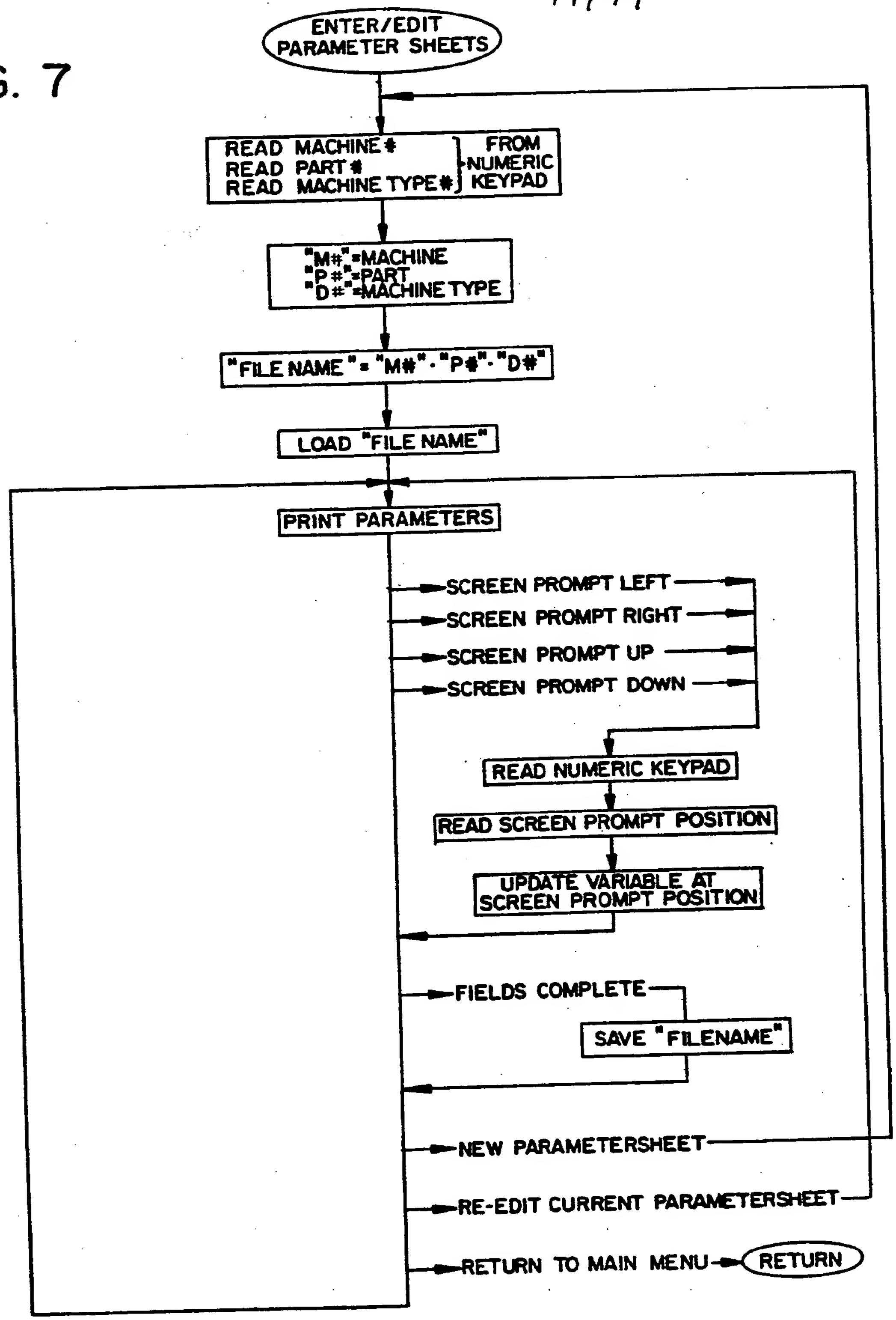

MAKE NEW
READ NUMBER KEY
"MT#"= NUMBER
SAVE "MT#" IN NON VOLATILE MEMORY
RETURN

FIG. 7


ENTER/EDIT PARAMETER SHEETS
READ MACHINE #
READ PART #
READ MACHINE TYPE #
FROM NUMERIC KEYPAD
"M#"=MACHINE
"P#"=PART
"D#"=MACHINE TYPE
"FILE NAME"="M#"·"P#"·"D#"
LOAD "FILE NAME"
PRINT PARAMETERS
SCREEN PROMPT LEFT
SCREEN PROMPT RIGHT
SCREEN PROMPT UP
SCREEN PROMPT DOWN
READ NUMERIC KEYPAD
READ SCREEN PROMPT POSITION
UPDATE VARIABLE AT SCREEN PROMPT POSITION
FIELDS COMPLETE
SAVE "FILENAME"
NEW PARAMETERSHEET
RE-EDIT CURRENT PARAMETERSHEET
RETURN TO MAIN MENU
RETURN

0126174

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 83 10 5037

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	US-A-3 945 255 (BISGAARD et al.) * Column 1, line 60 - column 2, line 11; column 2, line 37 - column 3, line 14 *	1,2	B 22 D 17/32 B 29 F 1/06
Y		6	
Y	EP-A-0 018 551 (SIEMENS A.G.) * Page 3, line 16 - page 4, line 17 *	6	
A	DE-A-2 615 445 (WESTFÄLISCHE METALL INDUSTRIE) * Page 4, last two lines - page 7, line 11 *	1,2,6, 11-14	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	MODERN PLASTICS INT., vol. 9, no. 3, March 1979, pages 13-15, Lausanne, CH "Process control: now it's an aid in everyday injection molding" * Page 14, right-hand column, lines 20-36; page 15, left-hand column, lines 24-37 *	1,2,6	B 22 D B 29 F
A	DE-A-3 142 811 (IDRA PRESSEN GmbH) * Abstract *	1,2	

--- -/-

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13-01-1984	SONIUS M.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503. 03.82

0126174

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 83 10 5037

Page 2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	US-A-4 335 778 (MOTOMURA et al.) * Abstract * -----	1,2,7	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13-01-1984	SONIUS M.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document